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THERMAL CONDUCTIVITY OF NORMAL BEET JUICE

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13. ABSTRACT

A bicalorimeter was used for thermal cond. measurements. It consists of 2 spheres, one within the other, the space between being filled with the test soln. which is heated to a required temp. and cooled in H_2O. The thermal cond. (w./m./°C.) is calcd. from the cooling rate. For press juice of >80 purity, it was almost identical with that of a refined sugar soln. of the same purity, but was ~22% greater than the beet thermal cond. At a purity of 80-7, the difference between measured and calcd. thermal cond. (the latter being given by 0.534-0.0026° Brix) was <1.5%. While the d. and heat capacity of beets and beet juice and the thermal cond. of beet juice conform approx. to the law of additivity, the thermal cond. of the beets does not. From Sugar Ind. Abstr. 27(10), 221(1965).

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THERMAL CONDUCTIVITY OF NORMAL BEET JUICE

M. Z. Khelemskiy and V. Z. Zhadan

Experiments for determining the thermal conductivity of normal juice were conducted in order to clarify the dependence of the thermophysical properties of a sugar beet upon the properties of cell fluid in that beet.

Thermal conductivity was determined by a method based on the regularities of the steady-state conditions.

A brass instrument known as a bicalorimeter was a "sphere within a sphere" system with a 3.66 mm gap between the spheres. This gap was filled by the juice. The whole system was heated with a liquid to a specified temperature and then cooled in vigorously agitated water. As a result of the experiment we found cooling rate m and by knowing it we calculated the thermal conductivity of the juice with the help of the equation

$$\lambda = m\frac{4.92\delta}{B},$$

where δ – the thickness of the gap between the spheres in m;

$$B = \frac{3p}{3p + 0.87}; \quad p = \frac{M}{c};$$

[1]V. Z. Zhadan – coworker of the Odessa Technological Institute of the Food and Refrigeration Industry.

M - the constant of the instrument;

c - the total heat capacity of the liquid layer and the envelope in kJ/deg.

The first series of experiments were conducted with water in order to check the instrument out. Results of these experiments are presented in Table 1.

Table 1.

Experiment Number	Water mass in g	Temperature in °C	Thermal conductivity λ W/(m·deg)*		Divergence in %
			Experimental data	Tabulated data	
1	25,04	24,0	0,622	0,606	+2,6
2	25,00	24,7	0,602	0,608	—1,0
3	25,00	24,7	0,602	0,608	—1,0

*1 Cal/(M·h·deg) = 1.163 W/(m·deg).

It is evident from the table that the divergence between the experimental and tabulated coefficients of thermal conductivity was within permissible limits.

The next series of experiments were conducted on sugar solutions of different concentrations prepared by the dissolution of refined sugar in distilled water. The components of the solution were weighed on an analytical balance.

Correlation of the experimental data led to the following calculating formula:

$$\lambda = 0{,}534 - 0{,}0026 n_{cyx},$$

where λ - the thermal conductivity of normal juice in W/(m·deg);

n_{cyx} - the dry matter content in %.

The divergences between experimental and calculated values were also within permissible limits (Table 2).

Table 2.

Experiment number	Dry matter content in %	Thermal conductivity λ W/(m·deg)		Divergence in %
		Experiment	Calculation	
1	8.0	0.582	0.597	+2.6
2	14.2	0.565	0.578	+2.3
3	20.0	0.554	0.561	+1.3
4	25.0	0.536	0.543	+1.3

The main series of experiments is conducted on normal beet juice whose quality fluctuates from 80 to 87%. The divergence for sugar solutions was less than 1.5% when the calculating formula was used.

Table 3 presents the thermal conductivity of normal juice.

Table 3.

Experiment number	Dry matter content in %	Thermal conductivity λ W/(m·deg)		Divergence in %
		Experiment	Calculation	
1	21.0	0.550	0.556	+1.06
2	21.0	0.549	0.556	+1.27
3	17.0	0.575	0.518	−1.21
4	22.4	0.549	0.551	+0.42
5	19.5	0.562	[illegible]562	0.00
6	21.5	0.554	[illegible]56	+0.42

The thermal conductivi · of normal juice is higher than that of a beet by almost 22%. It is evident from a comparison of the data in Tables 2 and 3 that when the quality of beet juice is higher than 80%, its thermal conductivity is close to that of a sugar solution of corresponding concentration.

The important question of the degree of approximation of the law of additivity for the thermophysical properties of a beet and beet juice was made clear. It was proven that this law is satis-

fied by the specific weight and heat capacity of the beet and the beet juice (approximately). Moreover, the following values are obtained: relative specific weight for the dry matter in the beet and in the beet juice is 1.42. The heat capacity of the dry matter in the beet and in the beet juice was $0.33 \cdot 4.182$ kJ[1]. The thermal conductivity of the dry matter in the beet juice is $0.31 \cdot 4.182$ kJ.

The values for the thermal conductivity and the temperature conductivity of the beet in out experiments does not conform to the law of additivity. Data available in literature confirm our conclusion. For example, the thermal conductivity for meat containing about 25% dry matter is $0.39 \cdot 4.182$ kJ.

From the equation of additivity, assuming for water $\lambda = 0.52$, we get the thermal conductivity for the dry matter in meat $\lambda_{cyx} = 0$. This is contradictory to our physical representations.

Thus, the widespread opinion on the possibility of using the law of additivity for the determination of the thermophysical parameters of food products in relationship to their thermal conductivity is not always confirmed.

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[1] 1 Cal = 4.182 kJ, or $4.182 \cdot 10^2$ J (extract from All-Union Standard / All-Union Committee for Standardization 6259).